NEW RESULTS OF ARCHIVE PANORAMIC IMAGE PROCESSING AND THEIR POTENTIAL IMPLEMENTATION FOR MORPHOLOGIC ASSESSMENT OF LUNAR SURFACE.

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Introduction: Russia has a long tradition in Lunar exploration, extremely successful in their early missions: the first imaging of the Lunar farside, the first soft landings, the first planetary rovers – Lunokhod-1 and -2. Lunokhod-2 has completed a traverse of more than 40 km and transmitted to the Earth about 80 panoramas of Lunar surface. Now Russia is preparing new Lunar missions to the South polar region of the Moon. The objectives of our work are to fully exploit the historic Lunokhod data based on LRO NAC photogrammetry image processing and use the results for detailed study of the properties and characteristics of the lunar surface.

The study: MIIGAiK takes part in PRoViDE (Planetary Robotics Vision Data Exploitation) project which aims to assemble a major portion of the imaging data gathered from different vehicles and probes on planetary surfaces into a unique database, bringing them into a spatial context and providing access to a complete set of 3D vision products (http://www.provide-space.eu/). Unfortunately, many of the relevant operational parameters of the Lunokhods mission are lost. Timing and positional information, as well as the geometric properties of the cameras are not known and must be determined in the process. New digital photogrammetry image processing of archive panoramas [1] is a key to solving these issues, providing analysis techniques, not available at the time of the early Lunar missions.

In order to recover lost information of Lunokhod missions (coordinates of observation points and tilts of the Lunokhod while taking panorama) and study landing site imagery by state-of-the-art photogrammetric techniques a special technology of new image processing of archive panoramas has been developed at MExLab. This technology allows us to assemble panoramas from scanned archive fragments (Fig. 1a) and resample them close to their original size. Horizontal panoramic cameras were rigidly mounted on Lunokhod and inclined at 15° downward from the horizontal plane. In addition, images were affected by the tilts of the Lunokhod itself. During the mission the tilts were determined by onboard devices, however, these data are lost or inaccessible so we have to define these parameters while bringing panoramas to the horizon (Fig. 1b). Due to construction of the panoramic cameras panoramas were obtained in spherical projection and have to be transformed into central projection for photogrammetric purposes (Fig. 1c). Next step is to perform panoramas in measurement form and create orthoimages for futher mapping and geomorphology analyses (Fig. 2). Such processing of Lunokhod panoramas simplifies their using for studies of lunar regolith, small craters, stones, etc. Moreover, it helps us to search for stereopairs and multiview points [2].

However, determination of exterior orientation parameters is still a very challenging task. We have photogrammetrically processed stereo LRO NAC images [3, 4], created detailed DEM and orthoimage for the region. Now our task is to pinpoint the observation sites on orthorectified LRO NAC images. The first way to do it is to fit orthorectified panoramas to the LRO NAC image manually. But practically everything what is seen on panoramas is too small to be identified on LRO images (which resolution is 0.3-0.5 m/pixel while in panoramas we can see details up to several cm). So, to make determination of Lunokhods' observation points easier we have developed a special software which allows us modeling the panoramic image taken from selected point of the route based on LRO NAC DEM and orthomosaic. Then we can compare artificially modeled panorama (Fig. 3) with the origin one which is supposed to be taken from that point (Fig. 4). After all panoramas are processed and identified it will be possible to continue the study [5] of Lunokhod area in more detail.

Conclusion: We have developed possibilities to study historic lunar panoramic images in combination with high-resolution LRO data. We derived terrain models and orthoimages of the sites for data fusion with the panoramic images obtained in-situ from the lunar surface. The fully reconstructed panoramas obtained by new photogrammetric processing techniques [6] provide morphology and morphometry information which can be used for quantitative surface analyses and extrapolating assessment of lunar polar area. Results of our work, including rebuilt archival panoramas, will be placed into a MIIGAiK planetary data Geo-portal (http://cartsrv.mexlab.ru/geoportal/).

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References:[1] Zubarev A.E. et al. (2013) *4M-S3*, PS-21. [2] Karachevtseva I.P. et al. (2013) *EPSC* #532. [3] Zubarev A.E. et al. (2012) *3M-S3*, 3MS3-PS-13. [4] Zubarev A.E. et al. (2012) *EPSC* #477. [5] Karachevtseva I.P. et al. (2013) *PSS Vol.85*, 175-187. [6] Mitrokhina L.A. et al. (2013) *ISPRS meeting* of the WG IV/8.

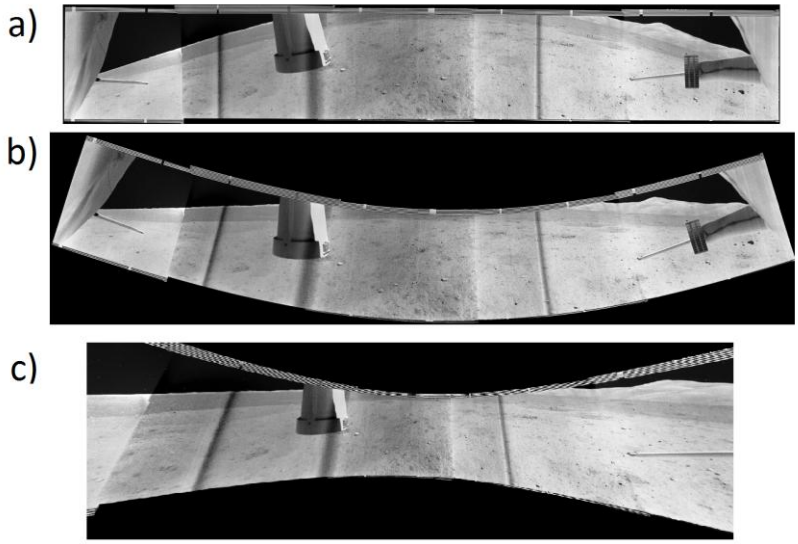

Fig. 1. Lunokhod-2 panorama a) assembled from archive fragments (spherical projection); b) assembelled and brought to the horizon (spherical projection); c) assembled, brought to the horizon, and transformed into central projection

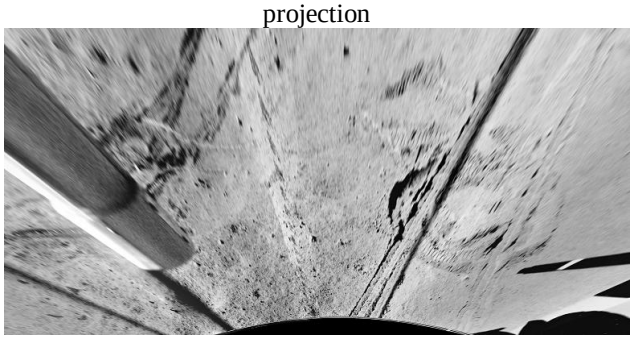

Fig. 2. A part of orthorectified panoramic image obtained by Lunokhod-2

Fig. 3. Panoramic image modeled at MExLab using LRO NAC orthoimage and DEM

Fig. 4. Assembled archive panorama for approximately same region as modeled panorama in Fig. 3